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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

DITCHING INVESTIGATION OF A $\frac{1}{24}$ - SCALE MODEL

OF THE DOUGLAS C-124 AIRPLANE

By Lloyd J. Fisher and John O. Windham

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DITCHING INVESTIGATION OF A $\frac{1}{24}$ -SCALE MODEL

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SUMMARY

An investigation of a $\frac{1}{24}$ -scale dynamically similar model of the Douglas C-124 airplane was made to determine the ditching characteristics and proper technique for ditching the airplane. Various conditions of damage, landing attitude, flap setting, and speed were investigated. The behavior of the model was determined from visual observations, motion-picture records, and time-history deceleration records. The results of the investigation are presented in table form, photographs, and curves.

It was concluded on the basis of results from model tests with scale-strength bottoms (equivalent to 1150 pounds per square foot, full scale) that the airplane should be ditched at a medium nose-high landing attitude (near 7°) with flaps full down. The airplane will probably make a smooth run with considerable damage resulting to the fuselage bottom just forward of the wing, but it is not likely that the water inflow will be overwhelming to personnel provided they are not in the belly compartment. Longitudinal decelerations in calm water will be about $2\frac{1}{2}g$ and the landing run will be about four fuselage lengths.

INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, an investigation of a model of the Douglas C-124 airplane was made to determine the probable ditching characteristics of the airplane and proper technique to be used in an emergency water landing. Of particular

interest in this investigation was the effect on behavior of the large clamshell doors in the nose of the airplane and the unusual shape of the fuselage bottom forward of the wing. A three-view drawing of the airplane is shown in figure 1. The tests were made in calm water at the Langley tank no. 2 monorail.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{24}$ -scale model had a wing span of 7.22 feet, a fuselage length of 5.26 feet, and a gross weight of 13.3 pounds. Photographs of the model are shown in figure 2. The model was constructed principally of balsa wood with spruce or mahogany at areas of concentrated stress. Internal ballast was used to obtain scale weight and moments of inertia.

The landing flaps were installed so that they could be held in the down position at approximately scale strength (designed for an estimated full-scale failing load of 140 pounds per square foot for the split flaps and 190 pounds per square foot for the inboard and outboard flaps). A calibrated thread was fastened between a wing bracket and a corresponding flap bracket so that loads on the flaps greater than the scale design load would break the thread and the flaps would return to zero.

The model was constructed so that sections of the relatively solid under part of the balsa fuselage could be removed and replaced with sections of known strength. These parts, called scale-strength bottoms, were designed and tested to fail under a uniformly distributed load of 1150 pounds per square foot (full scale). This strength approximates that of other transport airplanes of similar construction. The scale-strength sections shown in figure 3 were used to determine the points of maximum pressure and the amount of damage that might occur in a ditching.

Test Methods and Equipment

The test methods and equipment used were similar to those used in previous ditching investigations. The model was attached to the launching carriage on the Langley tank no. 2 monorail at the desired attitude with the control surfaces set to hold this attitude in flight. The model was then catapulted into the air and the preset control surfaces kept the model at approximately the desired attitude during the glide from release to landing.

The results of the investigation were obtained from visual observations, motion-picture records, and time-history deceleration records. The decelerations were measured with a single-component accelerometer located in the pilots' compartment. The natural frequency of the accelerometer was 20 cycles per second and it was damped to about 65 percent of the critical damping. The accuracy with which the instrument could be read was estimated at about $\pm \frac{1}{2}g$.

Test Conditions

All values given for the test conditions refer to the full-scale airplane.

Gross weight: A weight condition of 184,000 pounds was simulated in the tests.

Location of the center of gravity: The center of gravity was located at 32 percent mean aerodynamic chord and 46 inches above the thrust line of the inboard engines.

Landing attitude: Ditchings were made at three attitudes: 2° (near three wheel), 7° (intermediate), and 12° (near lift-curve stall). The attitude was measured between the fuselage reference line and the smooth-water surface.

Landing flaps: Tests were made with the flaps full-up, half-down, and full-down. Angular deflections for these settings are given in table I.

Landing speed: The landing speeds are listed in table I. They were computed from the power-off lift curves furnished by the manufacturer.

Landing gear: All tests simulated ditchings with the landing gear retracted.

Fuselage condition: The model was tested in the following fuselage conditions:

(a) Undamaged

(b) Scale-strength bottoms installed

RESULTS AND DISCUSSION

A summary of the results of the investigation is presented in table I. The notations used in the table are defined as follows:

Ran smoothly - the model made no apparent oscillation about any axis and gradually settled into the water as the forward speed decreased

Porpoised - the model undulated about the lateral axis with some part always in contact with the water

Trimmed up - the attitude of the model increased immediately after contact with the water

Sequence photographs of the model ditching at an attitude of 7° are shown in figure 4. Figures 5 and 6 present longitudinal deceleration curves as influenced by damage and landing attitude. Typical damage to the scale-strength bottoms is shown in figure 7.

Effect of Damage

The undamaged model usually made straight smooth runs. A tendency to trim up after contact with the water was evident at nearly all attitudes. The lengths of landing runs were about 5 to 9 fuselage lengths depending on the landing speed. The maximum decelerations recorded varied from $1g$ to $3g$.

When the model was tested with scale-strength bottoms installed, some damage always occurred. The bottom of the fuselage just forward of the wing sustained the greatest damage (see fig. 7). Little damage occurred to the fuselage bottom aft of the wing or to the clamshell doors. The model usually trimmed up so that the clamshell doors were not in the water during the high-speed part of the landing run and hence were not subject to high water loads. Consequently, they will have little effect on the ditching behavior unless the airplane is landed in a nose-down attitude or into a steep wave. The location and extent of damage was about the same for all landing attitudes, flap settings, and speed conditions tested. Because of the buoyancy of the low wing and the fact that the main floor is high above the damaged area, it is not likely that the water inflow will be overwhelming to personnel provided they are not in the belly compartment and the airplane is landed so that the clamshell doors are not subjected to high water loads. Generally, bottom damage caused the decelerations to be greater and the landing runs to be shorter than when no damage was simulated and the tendency of

the model to trim up in the water after contact was nearly eliminated (see fig. 4). The lengths of landing runs were about 4 fuselage lengths and the maximum longitudinal decelerations varied from $2\frac{1}{2}g$ to $5g$.

Effect of Flaps

When the model was tested with the flaps attached at scale strength in the down positions, the inboard and split flaps usually failed and there were no undesirable motions caused by the flaps. The longitudinal decelerations were lower, in general, when the flaps were full-down than when full-up or half-down. At the 12° landing attitude, however, the decelerations were highest with the flaps full-down. This was probably caused by the higher vertical speed associated with a near-stall landing attitude with flaps full-down.

Effect of Landing Attitude and Speed

The undamaged model had a tendency to trim up more at the lower attitudes than at the high attitudes, but the runs were long and smooth at all attitudes. When the model with scale-strength bottoms installed was landed in a nose-high attitude (near the stall angle), it pitched down abruptly on contact with the water and porpoised slightly with maximum longitudinal decelerations about $3\frac{1}{2}g$ to $4\frac{1}{2}g$ depending on speed. At a near-level attitude the runs were smooth but the decelerations were about $4g$ to $5g$ depending on flap setting. An intermediate landing attitude resulted in fairly smooth runs and the lowest decelerations ($2\frac{1}{2}g$ to $3g$). The best ditchings were made at this attitude with flaps full-down.

CONCLUSIONS

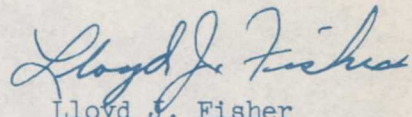
From the results of the investigation of a $\frac{1}{24}$ -scale dynamically similar model of the Douglas C-124 airplane with a bottom strength equivalent to 1150 pounds per square foot (full scale), the following conclusions were drawn:

1. The airplane should be ditched at a medium nose-high landing attitude (near 7°) with the flaps full-down.
2. The airplane will probably make a smooth run.

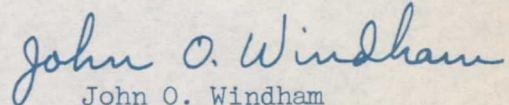
3. The fuselage bottom will be damaged (especially the part just forward of the wing) but it is not likely that the water inflow will be overwhelming to personnel provided they are not in the belly compartment.

4. When ditched as recommended, the maximum longitudinal deceleration in calm water will be about $2\frac{1}{2}g$ and the landing run will be about 4 fuselage lengths.


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JBB

TABLE I

SUMMARY OF RESULTS OF DITCHING INVESTIGATION IN

CALM WATER OF THE DOUGLAS C-124 AIRPLANE

[Gross weight, 184,000 lb; all values are full scale]

Landing attitude (deg)	Flap setting (deg) (1)	Landing speed (knots)	Length of run (ft)	Maximum longitudinal deceleration (g)	Motions of model
No damage					
12	40	91	676	$2\frac{1}{2}$	Ran smoothly
12	20	103	614	$1\frac{1}{2}$	Ran smoothly
12	0	123	890	2	Ran smoothly
7	40	96	787	1	Trimmed up, ran smoothly
7	20	112	787	$1\frac{1}{2}$	Trimmed up, ran smoothly
7	0	157	1132	2	Trimmed up, ran smoothly
2	40	109	725	2	Trimmed up, ran smoothly
2	20	135	1125	3	Trimmed up, ran smoothly
Scale-strength bottom installed					
12	40	91	480	$4\frac{1}{2}$	Porpoised
12	20	103	506	$3\frac{1}{2}$	Porpoised
7	40	96	504	$2\frac{1}{2}$	Ran smoothly
7	20	112	530	3	Porpoised
2	40	109	528	4	Ran smoothly
2	20	135	552	5	Ran smoothly

¹Split and inboard flaps deflected given amount, outboard flaps deflected one-half as much.



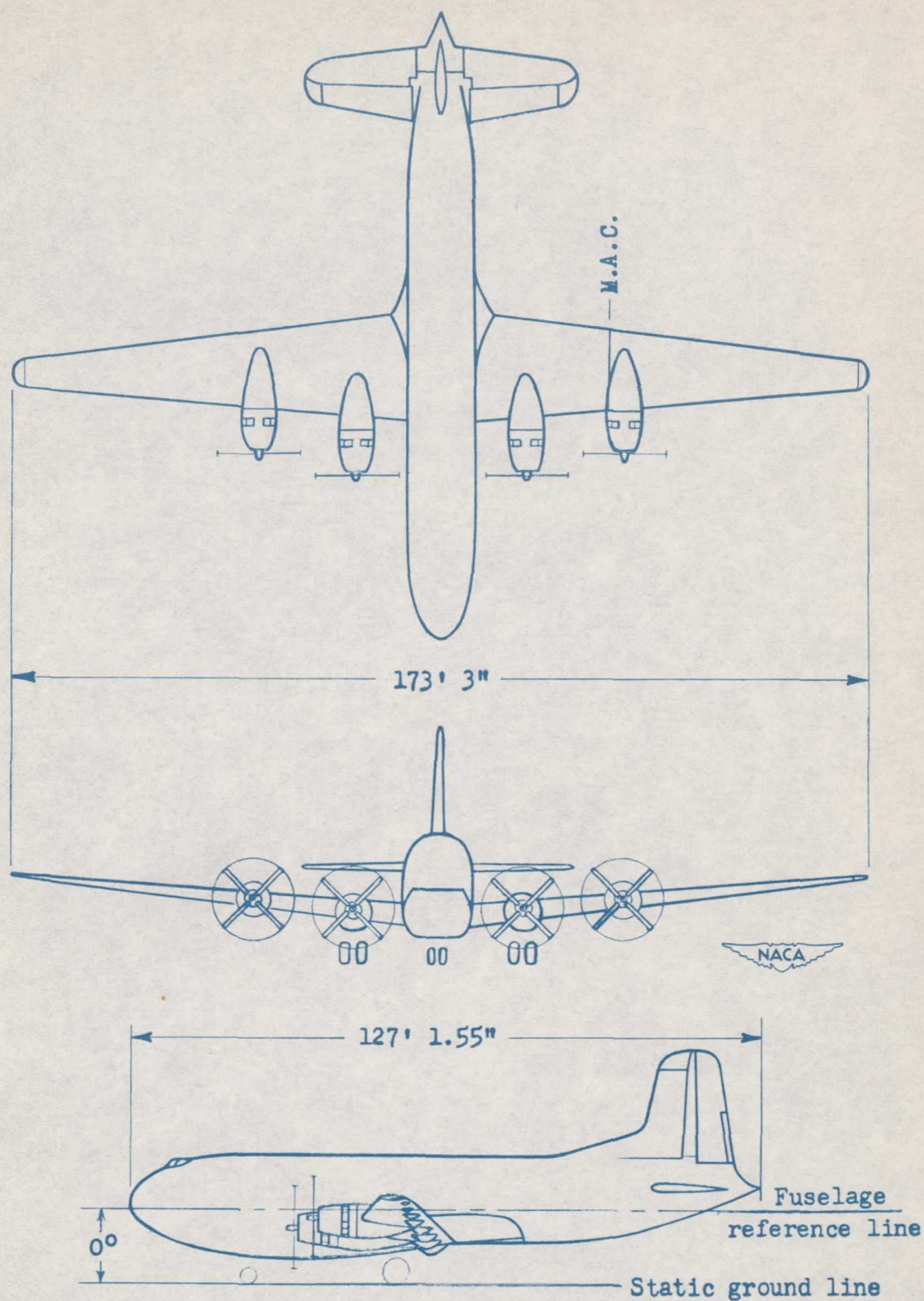
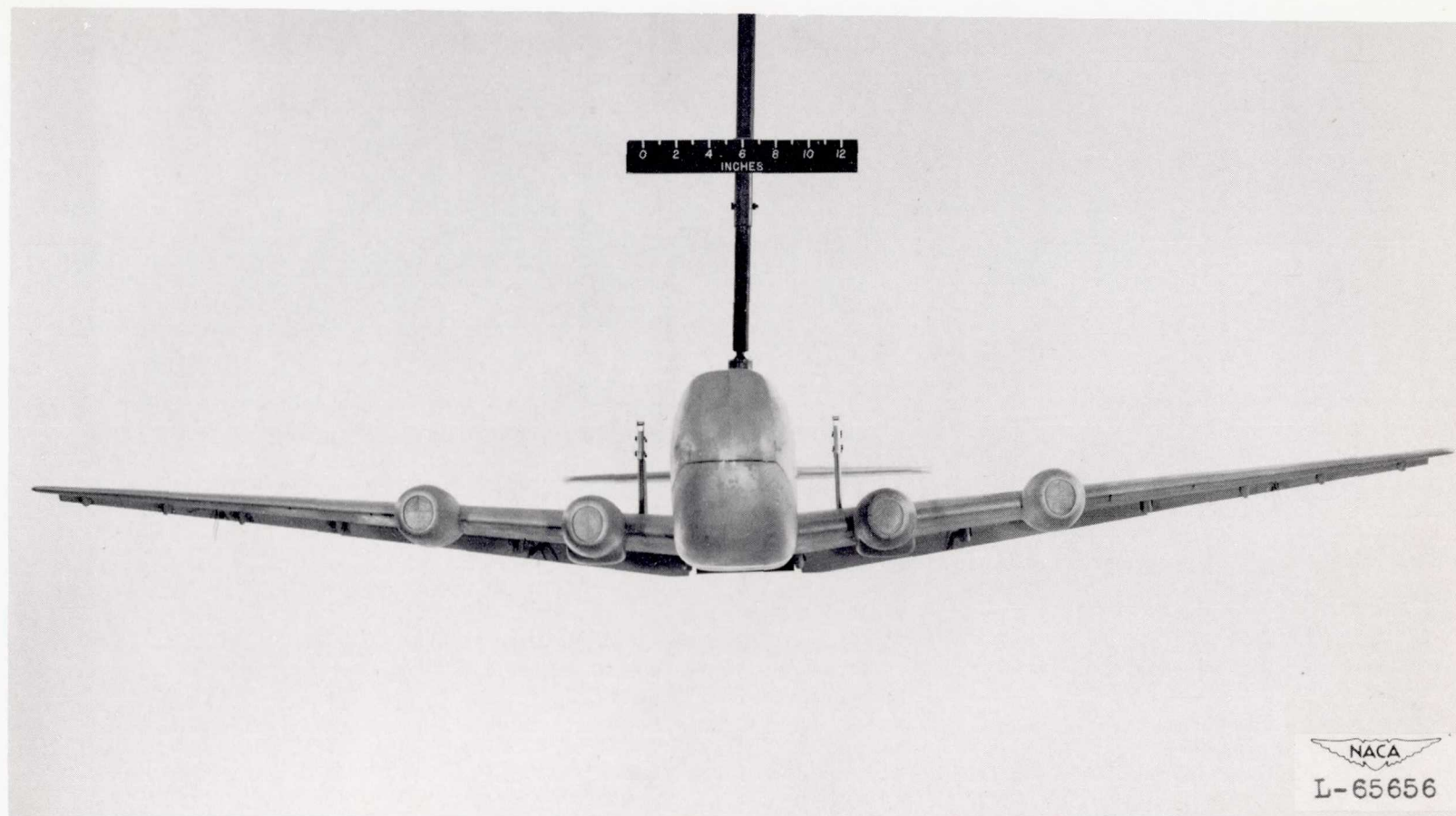
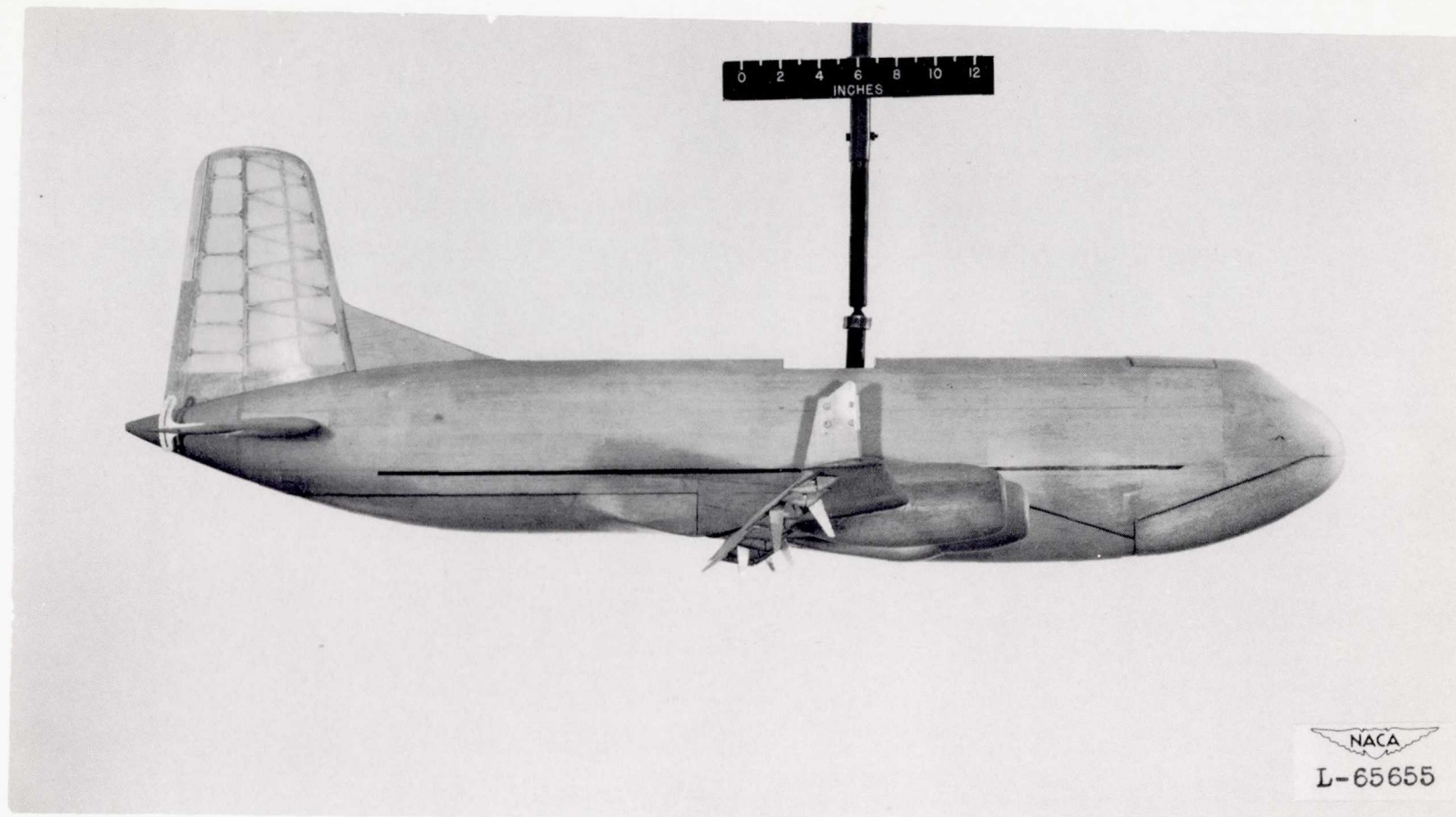


Figure 1.- Three-view drawing of the Douglas C-124 airplane.



(a) Front view.

Figure 2.- Model of the Douglas C-124 airplane.



(b) Side view.

Figure 2.- Continued.

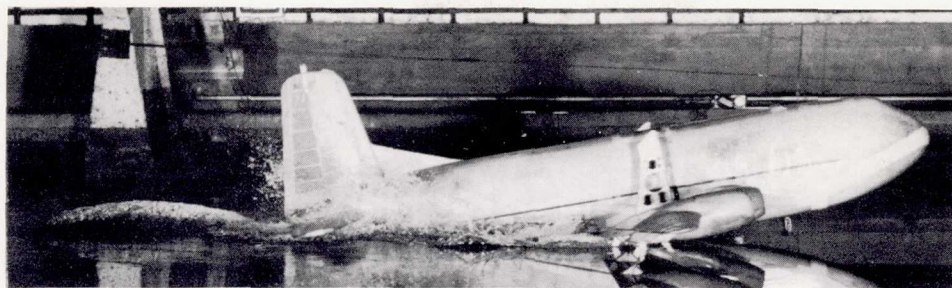


(c) Three-quarter bottom view.

Figure 2.- Concluded.



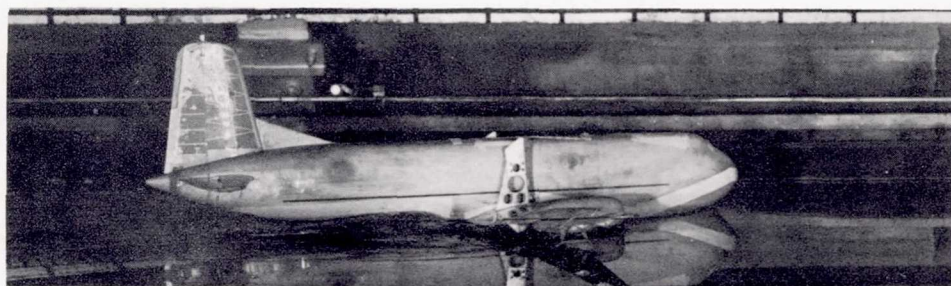
Figure 3.- Model with scale-strength bottoms installed.



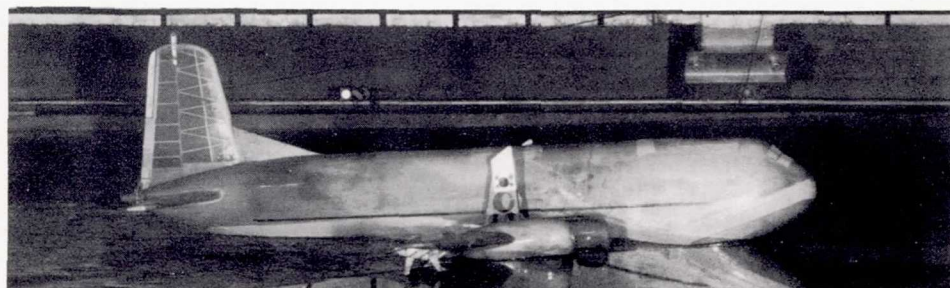
Near contact



192 feet



384 feet



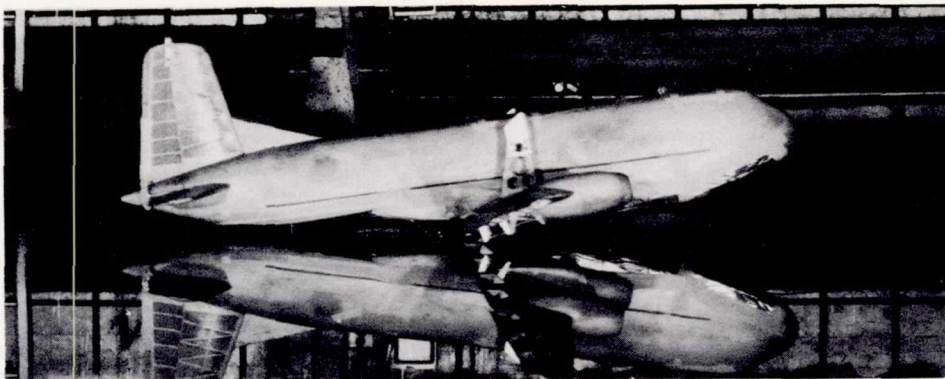
744 feet

(a) No simulated damage.

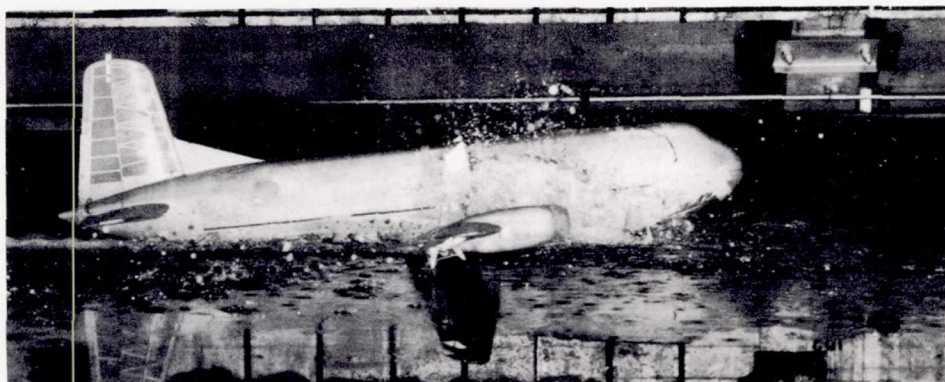


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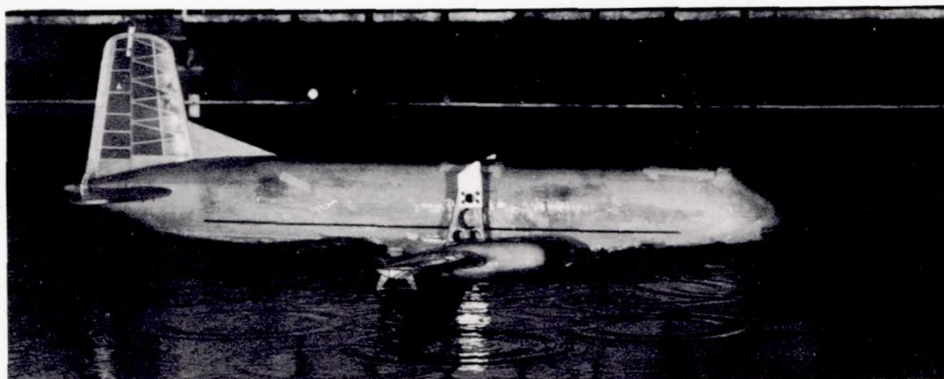
Figure 4.- Sequence photographs of model ditching at the 7° attitude with flaps full-down. Distances after contact are indicated. (All values are full scale.)



Near contact



290 feet



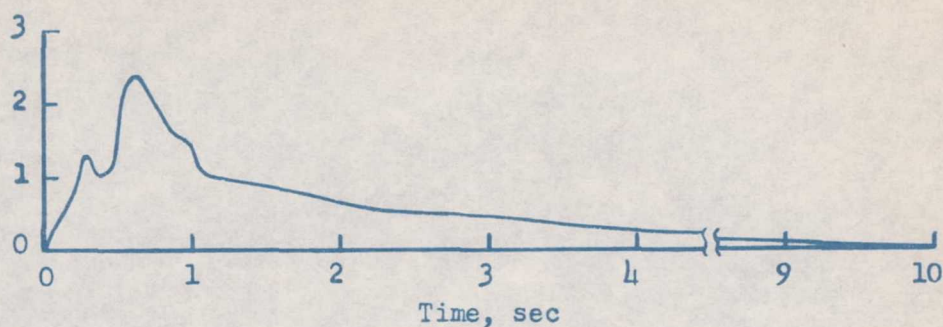
504 feet

(b) Scale-strength bottoms installed.

Figure 4.- Concluded.

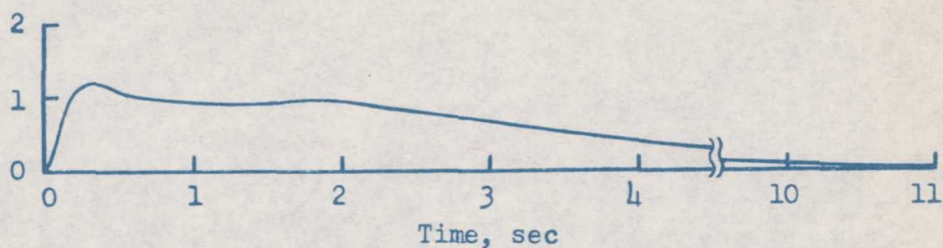


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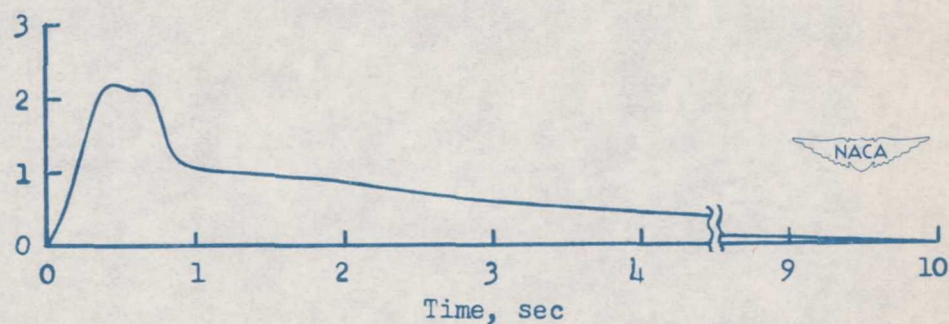


(a) Attitude, 12° ; speed, 91 knots.

Longitudinal deceleration, g

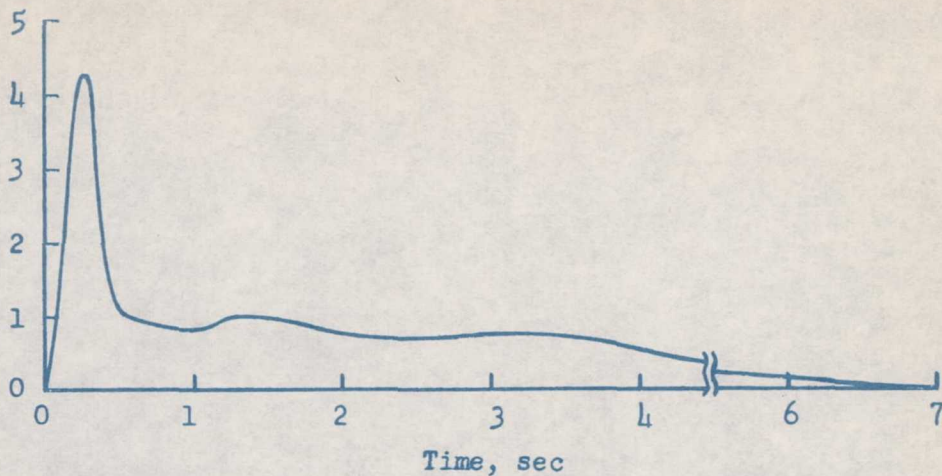


(b) Attitude, 7° ; speed, 96 knots.

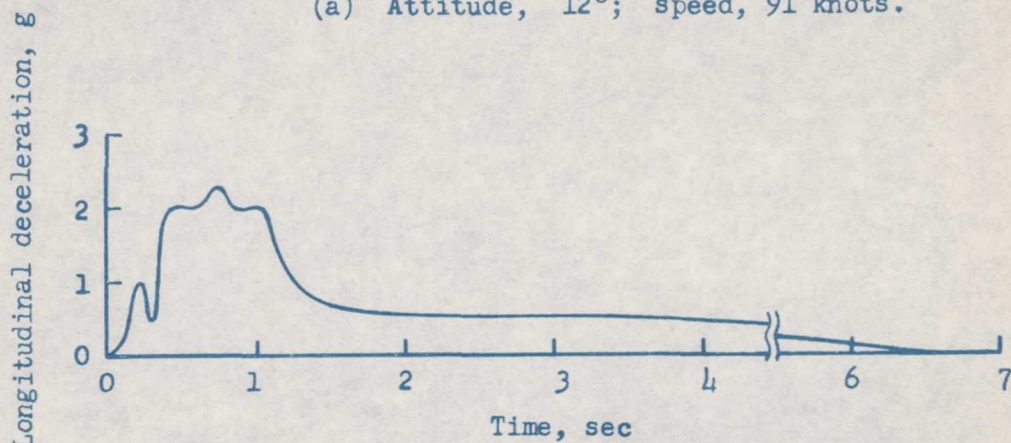


(c) Attitude, 2° ; speed, 109 knots.

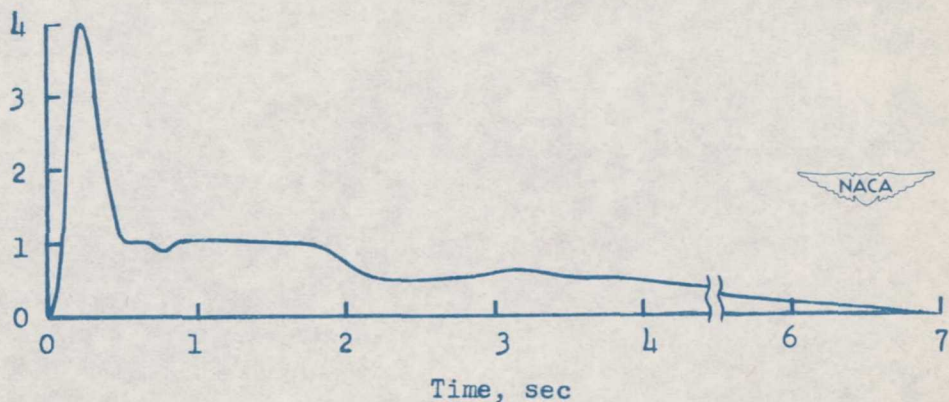
Figure 5.- Longitudinal decelerations at various landing attitudes and speeds. Undamaged condition; flaps full-down. (All values are full scale.)



(a) Attitude, 12° ; speed, 91 knots.



(b) Attitude, 7° ; speed, 96 knots.



(c) Attitude, 2° ; speed, 109 knots.

Figure 6.- Longitudinal decelerations at various landing attitudes and speeds. Scale-strength bottoms installed; flaps full-down. (All values are full scale.)



Figure 7.- Damage sustained by scale-strength bottoms at the 7° attitude with flaps full-down.